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BIOLOGICAL EVALUATION
Western Spruce Budworm

Kaibab National Forest
Grand Canyon National Park
Arizona

1980

Forest Pest Management
State and Private Forestry
Southwestern Region, USDA Forest Service
517 Gold Avenue, S.W.
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ABSTRACT

The western spruce budworm, Choristoneura occidentalis Free., continued to defoliate mixed conifer stands on the Kaibab National Forest and Grand Canyon National Park, Kaibab Plateau, for the sixth consecutive year. Acres defoliated from 1975 through 1980 were 781, 67,320, 70,720, 39,501, 53,811, and 38,426, respectively.

Damage surveys conducted in four stands in 1980 showed that 25, 36, 46, and 33 percent of the trees repeatedly defoliated were top-killed. In addition, tree mortality was observed for the first time in two of the four areas surveyed. The majority of these damages occurred to understory sapling and pole-sized trees.

Average egg mass densities increased substantially from those recorded in 1979. Areas defoliated in 1980 will sustain heavier defoliation in 1981. Heaviest defoliation will continue to occur in a 1- to 2-mile area on both sides of Pleasant Valley south from VT Hill and VT Lake on the Forest to about 2 miles into the Park.

The western spruce budworm outbreak is expected to continue for several more years on the Plateau.

Pest management alternatives and recommendations are discussed in this evaluation report.

INTRODUCTION

The western spruce budworm (WSBW), Choristoneura occidentalis Free., continued to defoliate mixed conifer stands on the Kaibab National Forest and Grand Canyon National Park, Kaibab Plateau, for the sixth consecutive year. Visible WSBW defoliation was first detected on the Plateau on 781 acres in 1975. Since then thousands of acres have been repeatedly defoliated on the Forest and Park. Total acres defoliated from 1976 to 1979 were 67,320, 70,720, 39,509, and 53,811 acres, respectively. Permanent tree damages, however, were documented for the first time last year (Parker 1979).

Tree damage and insect egg mass data were again collected in 1980 and are summarized in this evaluation. Management alternatives and recommendations are also presented.

TECHNICAL INFORMATION

Insect.--Western spruce budworm, Choristoneura occidentalis Freeman

Hosts.--Douglas-fir, Pseudotsuga menziesii (Mirb.) Franco
White fir, Abies concolor (Gord. & Glend.) Lindl.
Subalpine fir, Abies lasiocarpa (Hook.) Nutt.
Blue spruce, Picea pungens Engelm.
Engelmann spruce, Picea engelmannii Parry

Life History.--The western spruce budworm completes one generation each year (Furniss and Carolin 1977).

Stage	Time	Location on Host
Egg	August	On needles
Small larvae	Overwinter	In hibernaculum (silken cocoons) on branches and trunk
Large larvae	June	On buds and strobile
Pupae	July	On foliage
Adults	August	In flight

Evidence of Infestation.

1. Young larvae feeding on newly expanding buds and strobile.
2. Mature larvae consuming current year's needles.
3. Shoots webbed together by larvae.
4. Webbed shoots turning brown and falling from trees.
5. Defoliation most evident in upper crowns of trees.
6. Trees dying from the top downward after several years of heavy defoliation.

Extent of Defoliation in 1980.--Defoliation to host type was visible from the air on 38,426 acres (15,557 hectares) of the North Kaibab

Entomological Unit, Kaibab Plateau (Fig. 1, Appendix). Intensity of defoliation was categorized as light, 1,690 acres (684 hectares); moderate, 24,576 acres (9,949 hectares); and heavy, 12,160 acres (4,923 hectares).

BIOLOGICAL INFORMATION

Estimation of Damage.

Methods.--Damage surveys were conducted in four mixed conifer stands located in areas of heaviest defoliation. Overall, average tree damages would be lower than what is presented. The location and sizes of the survey blocks were: Dog Lake, 8 acres; Indian Lake, 6 acres; North Blowdown, 6 acres; and South Blowdown, 6 acres (Fig. 1, Appendix).

Fifteen to 20 variable plots (20 BAF) were sampled in four stands: Dog Lake, 20 plots, and Indian Lake, the North Blowdown, and the South Blowdown, 15 plots. At Dog Lake, 10 sample plots were systematically located on two cruise lines 2 chains apart, while sample plots at Indian Lake, the North Blowdown, and the South Blowdown were located along three cruise lines. Between-plot spacing was at 2-chain intervals in all survey blocks.

Fixed sample plots (1/100-acre) were superimposed on all variable plots in the Indian Lake, the North Blowdown, and the South Blowdown survey blocks to measure budworm damage to regeneration[1/]. No fixed sample plot data were collected in the Dog Lake survey block.

The species, diameter, and condition class (live, top-killed, and dead) of all count trees, including ponderosa pine, were recorded on both the variable and fixed sample plots. It is difficult to accurately determine if a tree has been top-killed by the budworm and only those trees that appeared obviously top-killed were recorded. Consequently, many trees that were completely defoliated in the upper crown which were not recorded as being top-killed may be dead or will die before next spring. The only accurate way to determine if a tree has been top-killed is to establish permanent plots and repeatedly check the tree for new growth or damage.

Results.--Data collected in the four survey blocks show that permanent tree damages continued to occur in mixed conifer stands. Percent top-kill ranged from 25 to 46 percent in areas surveyed in 1980, compared to 9 to 14 percent last year (Parker 1979). The incidence of top-killing is increasing in sawtimber-sized trees; however, the majority of the damage is still occurring in understory sapling and pole-sized trees. Top-killing was heaviest in white firs followed by Engelmann spruce and Douglas-fir, respectively.

1/ Regeneration-sized trees counted were 4.5 feet and taller to 4.9 inches in d.b.h.

Although damages noted consisted mainly of top-killing, several dead trees, presumably killed from repeated budworm defoliation, were documented for the first time in the Dog Lake and North Blowdown survey areas. Other damages expected to occur are growth loss and some understory mortality.

A summary of stand data for each survey block follows:

Dog Lake

	Saplings 2/, 3/	Poles 3/	Sawtimber 3/	Total
Total trees/acre	--	90	99	189
Live non top-killed trees/acre	--	59	83	142
Top-killed trees/acre	--	32	15	47
Dead trees/acre	--	--	1	1
Percent stand live non top-killed	--	31	44	75
Percent stand dead & top-killed	--	17	8	25

Indian Lake

	Saplings 3/	Poles 3/	Sawtimber 3/	Total
Total trees/acre	120	94	72	286
Live non top-killed trees/acre	53	91	39	183
Top-killed trees/acre	66	37	--	103
Dead trees/acre	--	--	--	--
Percent stand live non top-kill	18	32	14	64
Percent stand dead & top-killed	23	13	--	36

2/ No understory regeneration data was collected in this survey block.
3/ According to Region 3 Timber Management guidelines, saplings = .4 to 4.9 inches d.b.h.; pole timber = 5.0 to 8.9 inches d.b.h.; and sawtimber = 9+ inches d.b.h.

North Blowdown

	Saplings 3/	Poles 3/	Sawtimber 3/	Total
Total trees/acre	273	66	75	414
Live non top-killed trees/acre	147	18	52	217
Top-killed trees/acre	127	41	21	189
Dead trees/acre	--	8	--	8
Percent stand live non top-killed	36	4	12	52
Percent stand dead & top-killed	31	12	5	48

South Blowdown

	Saplings 3/	Poles 3/	Sawtimber 3/	Total
Total trees/acre	487	68	82	637
Live non top-killed trees/acre	340	43	41	424
Top-killed trees/acre	147	51	15	213
Dead trees/acre	--	--	--	--
Percent stand live non top-killed	54	7	6	67
Percent stand dead & top-killed	24	8	1	33

Relative Abundance of Pest

Methods.--Egg mass surveys were conducted in early August to provide an indication of the larval population for 1981, and subsequent defoliation. Two branches (70 cm in length) were cut from opposite sides of the midcrown of three sample trees on 20 plots scattered throughout the infested area (Fig. 1, Appendix). Sample trees met the following criteria: Douglas-fir, dominant or codominant; 30-50 feet in height; relatively open-grown with a full crown; and some budworm feeding evident, but not severely defoliated or top-killed. Each branch was individually bagged in cloth sacks, tied securely, labeled, and transported to a laboratory for examination. Foliage was stored in a walk-in cooler at about 40° F until examined.

In the laboratory, foliage was examined under ultraviolet light for egg masses. Needles with egg masses were classed as from current year's foliage, or a previous year's foliage, and kept separate in

3/ Ibid.

labeled pill boxes. New and old egg masses were separated under a stereomicroscope. All egg masses on current year's foliage were classed as new and their characteristics formed the basis for aging egg masses found on the previous year's foliage.

Defoliation estimates for 1981 were determined from the density of 1980 egg masses using the following information presented by McKnight et al. (1970):

Egg mass density a/	Predicted defoliation class b/
1.55	Undetectable for all infestations
1.71 to 6.20	Undetectable for "static" infestations Light for "increasing" infestations
9.30 to 31	Light for "static" infestations Moderate for "increasing" infestations
34.10	Moderate for "static" infestations Heavy for "increasing" infestations

a/ Number of egg masses per square meter of foliage.
b/ Defoliation class limits (percent of new growth).
Undetectable = $<$ 5 percent
Light = 5 to 35 percent
Moderate = 35 to 65 percent
Heavy = $>$ 65 percent

Results.--Egg mass data show that larval densities and defoliation will increase substantially on the Plateau in 1981 (Table 1, Appendix). Mixed conifer stands near all sample points, except 14, will experience moderate to very heavy levels of defoliation. Heaviest defoliation, however, will continue to occur in an area 1 to 2 miles wide on both sides of Pleasant Valley from VT Hill and VT Lake on the Forest to about 2 miles into the Park (Fig. 1, Appendix).

There was an average of 81.6 egg masses per meter square of foliage. This is a 3.16:1 increase over last year. However, since one of the criteria for selecting sample trees was that they not be heavily defoliated, the large increase in egg masses per unit area of foliage may be partially due to the movement of moths away from heavily defoliated trees to trees with more foliage for egg laying. A summary of the average egg mass data for the infestation follows:

	1976	1977	1978	1979	1980
New egg masses per m^2 of foliage	17.6	28.4	31.8	25.8	81.6 4/
Ratio of new egg masses in a year: new egg masses the previous year	0.9:1	1.6:1	1.1:1	0.8:1	3.16:1

4/ The standard error of the mean was 9.0.

Prediction of Trend.

The WSBW outbreak on the Kaibab Plateau is expected to range from moderate to very heavy levels in 1981. Defoliation is expected to increase in intensity on both the Forest and Park. Barring any natural factor(s) that could bring about the collapse of the outbreak, it is expected to continue for several more years. Heaviest defoliation, as previously mentioned, should continue to occur south of VT Hill and VT Lake on the ridges along both sides of Highway 67 on the Forest and for about 2 miles into the Park.

MANAGEMENT ALTERNATIVES

Maintain Present Management.--With this approach, the outbreak would be allowed to run its course until a population collapse occurred from a combination of: a) a lack of foliage to maintain a larval population; b) unfavorable weather conditions; c) heavy predation and parasitism; and d) a microbial epizootic. Adverse and beneficial effects of the outbreak would have to be accepted. These are:

1. This alternative would not be effective in preventing additional tree damages. Impacts to resource values and uses caused by the budworm would have to be accepted under this alternative. Although damages resulting from the WSBW in the Southwest are currently unknown, maximum damages similar to those estimated for the Pacific Northwest could occur if the outbreak continues unabated. These include the following:

Tree damages	Maximum damages (percent)
Growth loss	30
Understory mortality	25
Sawtimber mortality	5
Top-killing	25
Cone crop reduction	90+
Christmas tree use reduction	90+

2. There would be no direct costs associated with selection of this alternative although timber values will be affected and revenues reduced when severely damaged stands are harvested. Also, the depletion of the understory could necessitate the expenditure of funds for reforestation.

3. Visual qualities and economic and social impacts would result if this alternative was selected.

Silvicultural Management.--Silvicultural treatments in mixed conifer stands should be designed to create stand conditions that reduce tree damages. For example, prescriptions should: a) open up stands by logging, thinning, and burning; b) maintain stand densities favoring

ponderosa pine and aspen; c) favor prescribed burning to reduce the percentage of firs and Engelmann spruce; d) regenerate stands by artificial means using ponderosa pine stock; e) favor even-aged stands; and f) salvage damaged and insect-killed trees.

Effects of this alternative are:

1. The trend of the current outbreak would not be changed if a silvicultural program was initiated. Tree damages would be the same as those listed under the "Maintain Present Management" alternative.

2. Conversion of mixed conifer stands to a less susceptible state would be very costly; however, long-term benefits could be achieved.

3. Visual qualities and economic and social impacts would result if this alternative were selected.

Direct Suppression.--Aerial application of a pesticide registered by the Environmental Protection Agency (EPA) could be done to suppress the outbreak on the Forest. However, since the infestation on the adjoining Grand Canyon National Park would not be treated, one or two additional treatments may be required during the infestation cycle since treated stands could be reinfested from nearby areas that were not treated.

Application would be carefully timed to the development of the larvae, i.e., when 20 percent of the larvae are in the fifth and sixth instars. This would insure maximum effectiveness with a minimum dosage of insecticide. An application of this type is designed to utilize indigenous natural control agents to further reduce and maintain the budworm population at a low level.

Effects of this alternative are:

1. If a direct suppression program were to be carried out on the Forest in 1981, tree damages and losses occurring prior to treatment could not be prevented.

2. It would cost about $8.00 per acre to suppress the current outbreak. However, because of the permanent tree damages which occurred during 1980, it may no longer be economical to consider the direct suppression alternative.

3. Adverse environmental effects resulting from the aerial application of an insecticide would be minimal and temporary.

Insecticides registered for use against the budworm follow:

1. Carbaryl (carbamate insecticide)

The Sevin® 4 oil formulation of carbaryl has given consistently satisfactory results in suppressing budworm outbreaks throughout the West. An outbreak on the Santa Fe National Forest, New Mexico, was successfully suppressed in 1977, and the outbreak has remained at a low level for 4 [5/] years (Parker and Ragenovich 1980). Carbaryl is a non-persistent pesticide which is available for general use. One (1) pound of active ingredient per acre is the registered dosage rate, and no lasting environmental effects have been identified at this application rate.

2. Orthene® (organophosphate insecticide)

Orthene® is a non-persistent insecticide registered for use against the western spruce budworm and other forest defoliators. Although this insecticide has been shown to be effective against the budworm, it has never been used in the Southwest.

3. Malathion (organophosphate insecticide)

Malathion is a non-persistent, broad spectrum insecticide, registered for use against more than 100 insects, including the western spruce budworm. However, it is not recommended because it has yielded inconsistent results in suppressing outbreaks.

4. Microbial Insecticides

Microbial insecticides, such as *Bacillus thuringiensis* (*B.t.*), a bacterium, and viruses need further research testing and field evaluation before they are ready for use. In June 1980, several *B.t.* formulations were tested by the Pacific Northwest Forest and Range Experiment Station in conjunction with CANUSA [6/]. The results of this testing are still being evaluated.

Treatment of High Value Trees.--In recreation areas, VIS Centers and other areas where defoliation of high value trees would be unacceptable, individual or small groups of budworm-infested trees could be treated by a ground application of an EPA-registered insecticide to reduce the larval density and prevent the adverse effects of defoliation.

5/ 1980 field data unpublished.
6/ The Canada/U.S. Spruce Budworms Program (CANUSA--West) is a 6-year research and development program that is funded through 1983.

Effects of this alternative are:

1. Because only selected high value trees within an infestation could be treated, this would require a number of applications during the outbreak cycle since treated trees would be reinfested from the nearby infestation.

2. Application costs associated with this alternative would have to be accepted.

3. Adverse environmental effects would be minimal and temporary.

RECOMMENDATIONS

Management of the Current Western Spruce Budworm Outbreak--Kaibab National Forest

1. Short-term Pest Management.--Because substantial increases in permanent tree damages occurred during 1980, and since little would now be attained by implementing a WSBW control program this late into the infestation cycle, we recommend that the Kaibab National Forest maintain present management of the outbreak for the duration of this infestation cycle.

2. Long-term Pest Management--Long-term silvicultural management for WSBW on the Kaibab Plateau can be accomplished by including pest management considerations into timber and fire management programs. For example, management programs should facilitate the removal of susceptible old growth true firs and favor ponderosa pine, Douglas-fir, and aspen in mixed conifer stands.

LITERATURE CITED

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APPENDIX

Table 1.--Mean western spruce budworm egg mass density for 20 plots sampled on the North Kaibab Ranger District, Kaibab National Forest, 1980 (Fig. 1).

Sample plot	Egg masses/meter square
1	68.2
2	107.5
3	89.1
4	81.8
5	131.7
6	123.9
7	83.0
8	30.1
9	118.9
10	65.5
11	42.6
12	70.1
13	114.5
14	2.3
15	96.4
16	31.8
17	120.6
18	49.4
19	156.3
20	48.2

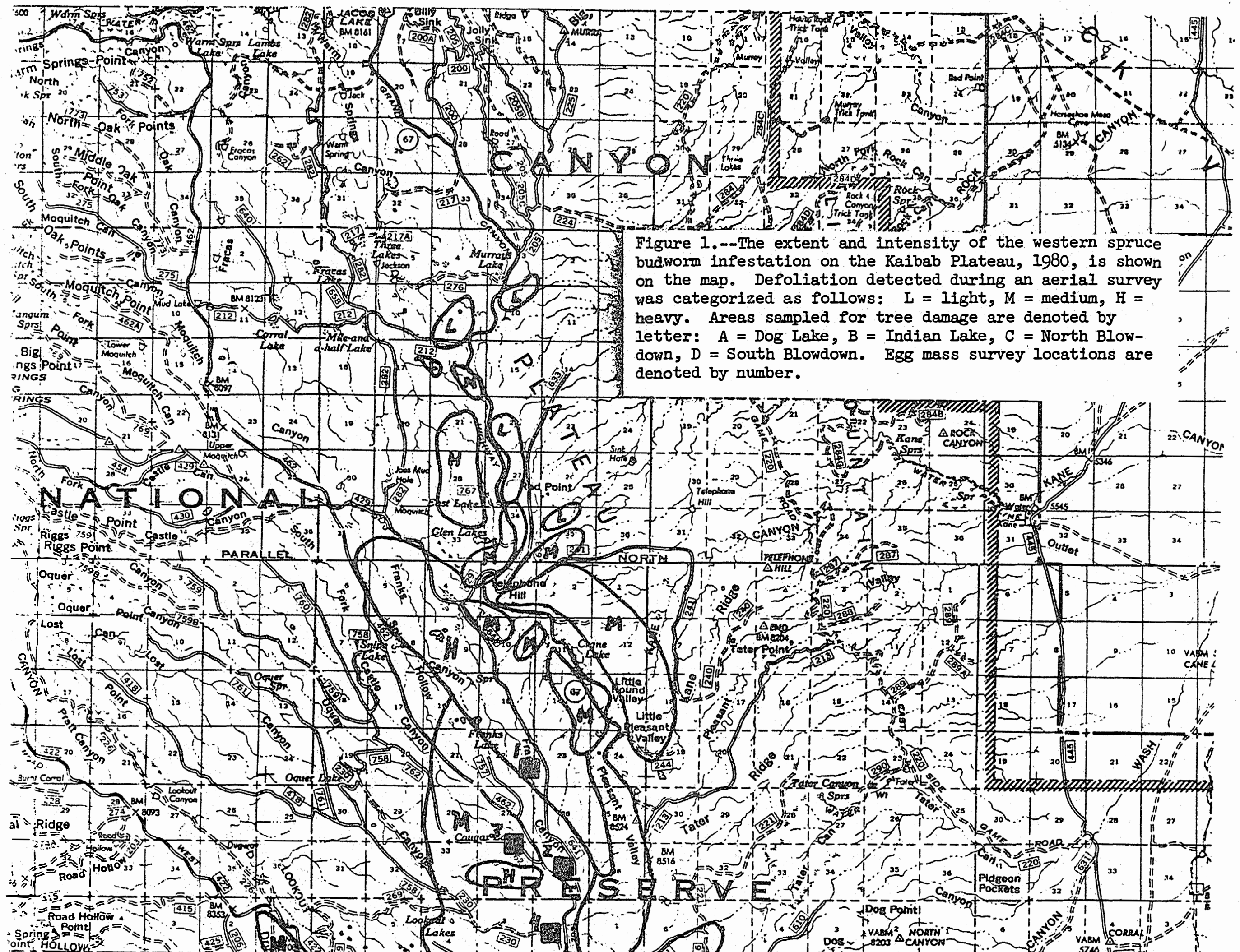

Figure 1.--The extent and intensity of the western spruce budworm infestation on the Kaibab Plateau, 1980, is shown on the map. Defoliation detected during an aerial survey was categorized as follows: L = light, M = medium, H = heavy. Areas sampled for tree damage are denoted by letter: A = Dog Lake, B = Indian Lake, C = North Blowdown, D = South Blowdown. Egg mass survey locations are denoted by number.